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Impact of Institutional Change on Irrigation Management: A Case Study from Southern Uzbekistan

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Abstract: The rapidly growing population in Uzbekistan has put massive pressure on limited water resources, resulting in frequent water shortages. Irrigation is by far the major water use. Improving irrigation water use through the institutional change of establishing water consumer associations (WCAs) has been identified as a way to increase agricultural production and meet the food demand in the area. However, most WCAs are not fully able to organize collective action or generate sufficient funds to carry out their responsibilities. This study investigated the water-resource-related challenges faced by WCAs and local farmers in Kashkadarya Province in Uzbekistan, using semi-structured expert interviews and focus group discussions. The resulting data were analyzed using qualitative analysis software (Atlas.ti). The results indicated that outdated infrastructure, poor governance, and farmers' non-payment of irrigation service fees hamper sustainable water management. Greater trust and communication within the WCAs would make an important contribution to effective collective action and to the long-term sustainability of local associations.

Keywords: collective action; common-pool resources; governance; irrigation infrastructure; Kashkadarya; sustainable development; water consumer association

1. Introduction

In many parts of the world, decreases in state funding for irrigation management in the late 20th century have led to the widespread deterioration of irrigation systems [1–3]. As a result, the responsibility for irrigation management has been transferred from government agencies to community-level water user groups [1]. These are generally promoted by either local government agencies or donor organizations. In some instances, self-initiated and self-organized community user groups have also formed, designing their own rules and imposing sanctions on rule-breaking individuals [4]. The main principle of these user groups is to charge for irrigation water delivery and

infrastructure maintenance through membership fees. However, such groups have experienced mixed results in various parts of the world, which can be attributed to various factors. Not all user groups have been successful in mobilizing the funds needed to improve irrigation systems. For instance, in examining two cases of Indonesian irrigation management, Vermillion [5] attributed inadequate infrastructure funding to poorly defined property rights for irrigation infrastructure at the farm level. This discouraged local irrigation associations from collecting the necessary funding or mobilizing labor for canal maintenance. Other researchers have found that conflicts regarding access to water, the scarcity of water due to poor management, and the shortcomings of existing institutions are some of the determinants for the lack of cooperation among resource users in irrigation management in Central Asia [6,7]. In a study focused on Kyrgyzstan and Tajikistan, Sehring [8] introduced the concept of institutional bricolage to explain the gap between formal and informal rules in the management of irrigation systems and infrastructure. She concluded that local actors' behavior is shaped and bounded by pre-Soviet and Soviet institutional patterns, which have impeded institutional change in the irrigation sector [8].

Ostrom [9] asserted that irrigation systems (water and infrastructure) can be classified as common-pool resources (CPRs) because of the difficulty of exclusion and the high degree of access. CPRs are natural or human-created resource systems. They generate finite quantities of resource units (such as water), and one individual's use of a unit makes it unavailable to others (irrigation water consumed by one farmer cannot be consumed by someone else), but there is a difficulty in excluding access (irrigation water flows through many farmers' fields). Hardin [10] described how each user of the commons would act to maximize their benefits from open access, while the costs of their use were shared between all users. As a result, the commons would be overexploited and eventually degraded.

However, access to CPRs is not always open. Common-property regimes exist under which shared ownership and rules dictate each resource user's access to and use of the resource [11]. When rules are adequately enforced under these regimes, CPRs are not always subject to degradation [11,12]. In response to suggestions that private property is the most efficient form of ownership [13,14] or state ownership is the best property regime [15], Ostrom [4] investigated the possibility of resource users organizing themselves and acting collectively. When a group creates rules that specify the rights and duties of its members, it can efficiently provide a public good from which all members can benefit [4]. This theoretical assumption has been seen to work well in practice in many countries (e.g., Albania, India, and Nepal).

Soon after the dissolution of the Soviet Union, there was a strong push by the government in Uzbekistan (the focus of this study) and by donors to establish user groups and collectively manage irrigation systems (a form of CPR) at the farm level. Growing problems with on-farm irrigation water management were a major reason for initiating the establishment of water consumer associations (WCAs) to manage the irrigation system through collective action [6]. When the Water and Water Use law of Uzbekistan was revised on 29 December 2009, the previously used term, "water users association," was changed to "water consumers association," based on the distinction that users do not necessarily affect the total amount of water available, but consumers do [3]. Between 1990 and 2000, the government experienced difficulty in providing adequate funding to maintain on-farm irrigation systems, and significant deterioration of the systems occurred. At the initial stages, the government and the donor community helped with resource mobilization and provided financial support. Donor agencies such as the Asian Development Bank, Swiss Development Cooperation, United States Agency for International Development, and the World Bank were especially active in facilitating the establishment of WCAs in Uzbekistan [16]. Similar externally supported initiatives have taken place in many other post-Soviet countries, including Bulgaria, Kazakhstan, Kyrgyzstan, and Tajikistan [8,17,18]. However, this initial support was insufficient to develop the WCAs into effective governance systems [19]. Most WCAs have been unable to ensure timely water distribution or generate sufficient funding to sustain their operation [3]. These two problems reinforce each other,

and thus, the associations continue to suffer from weak management and governance structures [3]. These are all well-known limitations associated with top-down approaches to collective action [10,20].

The aim of this paper is to assess the water management efforts of WCAs and farmers in the Kashkadarya Province, Uzbekistan, and to offer recommendations for improved water management at the WCA level. The study is based on the following hypotheses:

1. When a resource (e.g., water) generated from a CPR is highly valued and the users benefit from appropriating it under locally designed rules, effective cooperation in CPR management is likely to occur.
2. Communication with resource users and their active involvement in decisions about managing and maintaining the CPR are essential to improve information flow relating to the CPR's status and to learn about members' preferences.

2. Uzbekistan's Irrigation Reforms

Uzbekistan is Central Asia's most populous country. Its 31 million citizens (34% under the age of 14) comprise nearly half of the region's total population [21]. The rapidly growing population has put massive pressure on limited water resources, which has led to water scarcity and the deterioration of water quality [22,23]. The management of water resources in the Aral Sea Basin is a highly complex process that is further complicated by the rising demand for energy and food, environmental degradation, and increased pressure on the region's finite water resources due to economic development, population growth, and climate change [24].

The ongoing competition between agriculture and hydropower for water has implications for the country's sustainable development [25,26]. In semiarid Uzbekistan, improving water use technologies has been identified as a way to increase agricultural production [23] and meet people's food demands. The introduction of low-cost water-saving technologies and the improvement of on-farm irrigation systems have been found to be the main ways to reduce agricultural water demand and improve the quality of this valuable natural resource [27,28].

Prior to Soviet occupation, about 1.3 million ha of agricultural land was irrigated, with all canals and ditches owned and controlled by local communities [29]. Irrigation was mainly carried in foothill areas, floodplains, and the deltas of large rivers such as in the Amudarya, Syrdarya, Zarafshan, and Ferghana Valleys [30]. As a result of efforts to boost the Soviet Union's economy, an additional 3 million ha of land came under irrigation. Irrigation and drainage facilities were designed to accommodate the needs of large-scale farming, which were managed and owned by the state. The production of cotton became a leading industry, making a significant contribution to the national economy. Farmers in Uzbekistan produced about 0.6 million tons of raw cotton in 1913 on 1.3 million ha of irrigated land. In 1972, almost 10 times as much was produced, with a total of about 5.3 million tons of raw cotton on 2.7 million ha of irrigated land [30]. Currently, Uzbekistan produces about 3.7 million tons of raw cotton on about 4.2 million ha of irrigated land [31]. This is a severe drop in per-hectare production since independence from the Soviet Union. Cotton production was indispensable for the state during the Soviet era (1920–1991). Large-scale irrigation schemes were constructed to secure the Soviet Union's "cotton independence". Agriculture focused heavily on cotton, which required intensive labor and irrigation. Production targets for the *kolkhoz* (collective) and *sovkhoz* (state) farms, as well as product prices, were set by the state [32]. Even after its independence from the Soviet Union, Uzbekistan has retained the system of state planning for its main agricultural products, cotton and wheat.

Water reforms for the agricultural sector began in 2003 with Decree No. 320 of the Cabinet Ministers of Uzbekistan, Improvement in the Organization of Water Resources Management [3]. A key element of the reform was the creation of a multilevel water management system, made up of 10 basin irrigation system authorities (BISAs), each overseeing several smaller irrigation system authorities (ISAs), and each of these in turn containing several WCAs. Uzbekistan's 63 ISAs are responsible for maintaining the main canals, ensuring the sustainable use of water, and providing water to WCAs on

agreed schedules and in agreed amounts. To oversee this system, the Department of Water Resources was established in the Ministry of Agriculture and Water Resources.

The WCAs, covering on average 1500–3000 ha each, are diverse. They were established in the places of the dismantled *shirkat* farms (*shirkats* were large farm enterprises oriented to family-based production, which were established after Uzbekistan's independence to replace the *kolkhoz* and *sovkhoz* farms. The *shirkat*'s production output had to be delivered to the state). In Samarkand, for instance, WCAs were established in the place of district water departments [16], and in the Ferghana Valley, they were established mostly according to the hydrographic boundaries of the secondary and tertiary irrigation canals. The main responsibilities of WCAs in Uzbekistan are to ensure reliable water distribution to farmers; determine and collect irrigation service fees (ISFs) to fund WCA services; resolve disputes over water use and the management of irrigation and drainage systems in an appropriate, transparent, and democratic manner; maintain, rehabilitate, and improve irrigation and drainage systems; and monitor water use based on an agreed delivery schedule.

At the beginning of the 2000s, the authorities in Uzbekistan decided that agricultural productivity should be increased by land reform. This meant that the state ownership of the land was retained, but lifelong land use rights were introduced [33]. For this purpose, presumptive farmers applied for land use rights in a tendering process. A committee reviewed the applications and awarded land parcels based on the applicants' farming qualifications and fulfillment of certain other requirements (such as owning agricultural machinery and having a university degree). Priority was given to those who had been members of a *kolkhoz*, *sovkhoz*, or *shirkat* [3]. Market liberalization, however, also resulted in an increase in water use [34].

3. Materials and Methods

3.1. Study Area

The study area is located in the Kashkadarya Province, in the southern part of Uzbekistan, and in the lower reaches of the Amudarya River (Figure 1). The province covers an area of about 28,570 km² and has about 514,000 ha of irrigated farmland. The population is about 3 million, of which about 60% live in rural areas and depend on irrigated agriculture. The province consists of 13 districts and the provincial capital, Karshi. The study was conducted in June 2016.

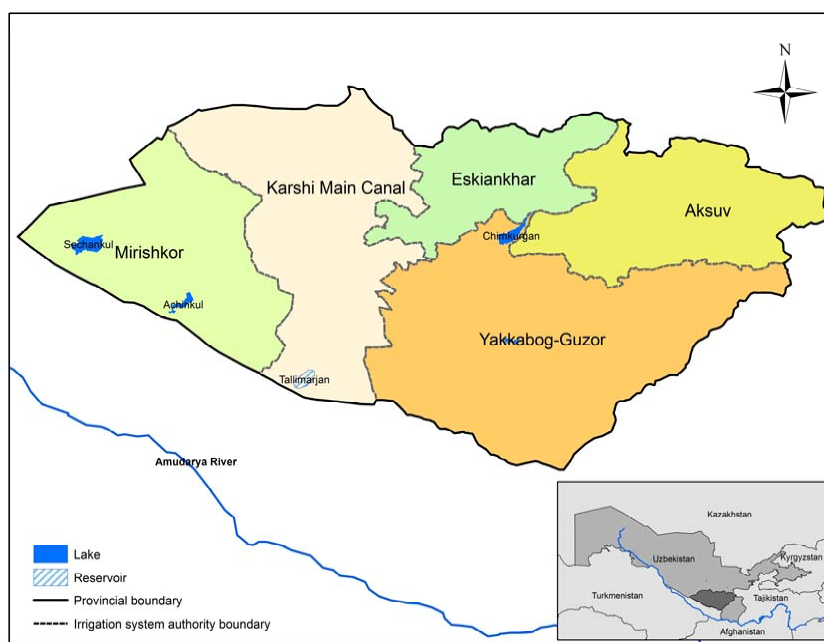


Figure 1. Location of the study area in Kashkadarya Province, including five ISAs.

Kashkadarya has an ethnically diverse population (including Uzbeks, Tajiks, Turkmens, Russians, and Tatars). The temperature ranges from $-2\text{ }^{\circ}\text{C}$ in winter to above $30\text{ }^{\circ}\text{C}$ in summer [35,36]. The province experiences frequent water shortages. The average annual precipitation is about 245 mm and the average annual potential evapotranspiration is above 1240 mm, resulting in a substantial annual deficit [35]. Thus, large-scale irrigation is essential.

Soil salinization is the main agricultural challenge in the province. About 45% of irrigated lands are salinized to some degree. Groundwater, on average 2–3 m below the surface, is also significantly salinized [37]. The capillary rise of groundwater, together with intense evapotranspiration, has led to strong salt accumulation in the upper soil surface. The traditional way of combating salinization is the application of large amounts of water to induce leaching. Soil types in the irrigated areas of Kashkadarya are dominated by sierozems, with a recent increase in solonchaks and solonetzts [38].

During the design of the Karshi Steppe Reclamation Program in the 1960s, it was anticipated that the groundwater table would rise in the province due to the introduction of large-scale irrigation. Thus, surface and sub-surface drainage systems were designed and implemented. However, on-farm drainage canals are now 40 years old, and most of them function poorly. As a consequence, the groundwater table has risen in many parts of the province, which has a considerable negative impact on crop yields. Waterlogging and soil salinity are major burdens for many farmers in Kashkadarya [39].

3.2. Irrigated Agriculture in the Study Province

Kashkadarya Province plays an important role in the economy of Uzbekistan. It produces natural gas, agricultural products (cotton, wheat, fodder crops, fruits, and vegetables), and raw materials for construction. About 75% of the water is supplied by the Amudarya River through a cascade of pumping stations. The remaining water comes from the Zarafshan River through the Eskiankhar canal (5%) and from the Kashkadarya River and other internal rivers (20%) (personal communication with Amu-Kashkadarya BISA official in 2016). Prior to the occupation by the Soviet state, the local population in Kashkadarya was primarily engaged in grain cultivation and some gardening [35]. Beginning in the late 1920s and early 1930s, the Ministry of Land Reclamation and Water Resources worked to expand the irrigated areas, promote a more effective use of machinery, create new irrigation systems, and develop and improve existing systems [40]. As a result, the irrigated land in the province increased from 63,000 ha in 1915 to 514,000 ha in 2010 [35]. This increase was due to an ambitious hydraulic program, comprising the construction of dams, irrigation canals, pumping stations, other facilities, and in particular, the gigantic Karshi Steppe Reclamation Program [35].

Presently, there are about 21,000 active farmers in the province. Mirishkor district (where two of our selected WCAs are located) has 1502 farmers. About 90% of them were born in the district and they or their parents have worked there during the *kolkhoz* and *sovkhoz* era. About 10% come from other parts of Uzbekistan. Most of the farmers in the district have an agricultural background (with experience in agronomy, water engineering, agricultural mechanization, or veterinary medicine). According to statistics from the Mirishkor district authorities, about 24% of farmers are 21–36, 43% are 37–51, and 33% are 52–67 years old. In terms of the average water consumption in the Mirishkor district, wheat consumes $4500\text{--}5000\text{ m}^3/\text{ha}$ and cotton $6500\text{--}7000\text{ m}^3/\text{ha}$ during a growing season. While salinity and waterlogging are the main factors for yield reduction, the lack of access to agricultural machinery has also contributed to yield decline. However, local experts believe that the recent initiative by the Ministry of Finance of Uzbekistan to establish a Melioration Fund could be an opportunity to allocate some funding for cleaning on-farm drainage systems. This, in turn, could improve productivity and combat salinization (personal communication with Amu-Kashkadarya BISA official in 2017).

The major water consumer in Kashkadarya is agriculture, with 514,000 ha of farmland under irrigation. The Amu-Kashkadarya BISA's crop allocation plan for 2016 called for over half of the cultivated land in Kashkadarya Province to be devoted to cotton and wheat, and the rest to fruits (including grapes and mulberry), fodder (including alfalfa, barley, and maize), vegetables, household garden plots, and other crops (Figure 2). The growing (*vegetacionniy*) season is from April to September.

Irrigation takes place primarily during that time, and light irrigation and large-scale maintenance of the water infrastructure are carried out during the rest of the year.

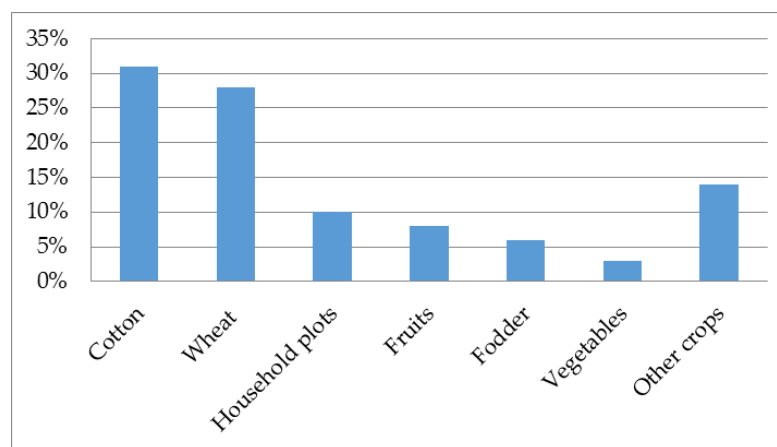


Figure 2. Crop allocation plans for Kashkadarya Province in 2016.

Water from the Amudarya River is typically lifted over 130 m by seven pumping stations and discharged into the Talimarjan reservoir. The conveyance capacity of the pumping stations is estimated to be 175–195 m³ per second [35].

Over 60% of irrigated land in Uzbekistan receive at least part of the water from pumped supplies [41]. Bucknall et al. [41] conducted an economic analysis of pumped irrigation in Uzbekistan and reported that, under the current price projections, almost all pump-supplied land in the country could be profitably farmed. However, their results for Kashkadarya Province require careful interpretation. If crop prices fall by 10%, pump irrigation in the province would become unprofitable. Under this scenario, farmers could adjust by either shifting away from wheat to more profitable crops such as cotton or fruits and vegetables, or by using water more efficiently [41]. In general, the cost of pumping water from the Amudarya River is covered by the state in Kashkadarya. However, farmers at the tail-end of canals may not have enough water for irrigation. In this case, they may use drainage water for irrigation and install small pumps to lift water from the drainage water surface, for which they would pay the electricity costs by themselves (personal communication with Amu-Kashkadarya BISA official in 2017).

3.3. Selection of Case Studies

Of the 152 WCAs in Kashkadarya Province, eight were chosen for closer study. The selection was not a trivial task. Social scientists have suggested different strategies for choosing study cases that have the greatest potential to improve understanding [42,43]—in this study, to test the hypotheses about the effectiveness of common-pool resources management.

This study used the most-similar-cases design (MSCD), in which sample cases are chosen that are as similar as possible, with regard to as many characteristics as possible, and thus are optimal for comparative research. This approach is designed to analyze a minimum of two cases and is one of the oldest recognized techniques of modern qualitative analysis, first introduced as a “Method of Difference” in Mill’s [44] classic study, *A System of Logic* [45,46]. It seeks to answer why outcomes differ when the subjects share similar characteristics [47].

Some social scientists criticize this approach, particularly when different nations or continents are compared, arguing that the number of conditions that can be kept constant is quite limited [46]. It was, however, very useful in the present study, in which the subjects are relatively similar and close. The study WCAs are all in Karshi Main Canal or Mirishkor ISA in the Amu-Kashkadarya BISA in Kashkadarya Province.

The WCA selection was guided by relevant studies [7,17], as well as secondary data obtained from the Amu-Kashkadarya BISA. The latter data were also used to guide the qualitative interviews. Criteria were: (1) the WCA manager's education level and work experience, ranging from a university degree with a water-management specialty to a secondary-school degree and no water-management background (on the assumption that these would affect a manager's ability to overcome WCA management challenges); and (2) the closeness of the CPR (i.e., irrigation systems) to the main water source and to the WCA members. The eight WCAs selected for the study are representative of the province as a whole and share similar climatic characteristics, but differ in their success in water management (Table 1).

Table 1. WCAs selected for the study.

WCA	District	Manager's Education (Specialization)	Canal Location	Irrigated Area (ha)	Number of Members	Number of Interviewees (Female)
Kuhnasoy Kashkadarya	Karshi	University (irrigation)	Head	4006	72	3 (0)
Muglon Obi Hayoti	Kasbi	University (irrigation)	Tail	4887	127	4 (1)
Zargar Tong Yulduzi	Koson	University (irrigation)	Tail	3789	46	9 (0)
M.Murot	Nishon	Vocational school (general)	Head	2588	37	5 (0)
Chashmai Mirob	Mirishkor	University (agriculture)	Head	3150	60	5 (0)
Tuychi Ogli Mamurjon		Vocational school (agriculture)	Tail	3200	84	13 (3)
Turkiston	Muborak	University (irrigation)	Tail	6461	68	4 (0)
Olovhon Farhod		Vocational school (general)	Tail	3000	58	6 (0)

3.4. Data Collection and Analysis

The empirical work was based on focus group discussions (FGDs) with WCA members and semi-structured interviews with local water authorities (e.g., ISA and BISA officials). Bitsch [48] defined an FGD as a research technique appropriate for collecting empirical data through group communication on a particular topic. This technique is intended not to facilitate decision-making or educate people, but to collect data, particularly when the resources required to conduct individual interviews are limited [48]. In this study, each FGD had between four and six participants (although we would have liked to conduct FGDs with the same number of participants in all eight WCAs. However, some WCAs had fewer or more participants than anticipated); WCA members who were relatively homogenous in terms of age, education, profession, and socioeconomic status; a moderator; and an assistant who recorded the discussions and kept notes [49]. The study team asked WCA managers to gather members at a WCA office for an FGD. This selection method may have introduced biases, and irrigation and canal maintenance duties may have prevented some farmers from attending. Thus, future research should take into consideration these shortcomings in the selection process. An additional limitation was that we lacked full information about the political and social connections between WCA managers and farmers due to limited financial resources.

FGDs and expert interviews were audio-recorded when the respondents consented. These recordings were transcribed and, like the field notes, analyzed using qualitative data analysis software (Atlas.ti, Version 6.2, ATLAS.ti Scientific Software Development GmbH, Berlin, Germany), which enables the retrieval of data based on various criteria, such as the occurrence of specific words, number of coded instances, and key statements to be quoted in reports [50]. The main objective of this analysis was to study resource users' views on CPR management and on the most important challenges facing

their WCAs. A coding structure (coding schemes grouped into code definitions) was developed and used to identify the most common themes and their frequency (Table 2).

Table 2. Coding structure for the Atlas.ti analysis.

Coding Scheme	Code Definition
Household community canals	Lack of support from households
Conflict dispute clash	Poor condition of irrigation canals
drainage waterlogging salinity fertility	Frequent conflicts over water use
scarce shortage	Improper drainage systems
WCA excavator crane machinery	Acute water shortage
electricity pumps	Lack of agricultural machinery
debts salary ISF	High pumping cost
	Lack of funding to pay WCA staff

For ethical reasons, we kept respondents' names private and did not report any information given in the FDGs that could affect the participants' livelihoods.

4. Results and Discussion

To illustrate the challenges and opportunities facing the selected WCAs, this section presents a detailed review of the performance of two of the eight WCAs covered by this study—Muglon Obi Hayoti in the Karshi Main Canal ISA and Chashmai Mirob in the Mirishkor ISA based on information shared during the FDGs and qualitative interviews. It also discusses the potential causes behind problems identified in the eight investigated WCAs.

4.1. WCA Characteristics

The two WCAs selected for in-depth analysis generally represent two ISAs (Karshi Main Canal and Mirishkor ISAs). Our selection was based on the head–tail canal location and donor–non-donor funding. Out of the eight WCAs, only one received funding from a donor organization (Chashmai Mirob WCA). Thus, it was chosen for in-depth analysis. Since the WCA was situated in the head of the canal, the other WCA was supposed to be situated in the tail. Randomly, out of the four WCAs located in the Karshi Main Canal ISA, we selected the Muglon Obi Hayoti WCA for this purpose.

4.1.1. Muglon Obi Hayoti WCA

This WCA is located in the Kasbi district and was established in February 2007 based on Cabinet of Ministers Decree No. 8, 2002, Measures for the Reorganization of Agricultural Enterprises into Individual Farms. It was created on the territory of a poorly functioning *shirkat*. According to the manager, as of June 2016, the WCA had 127 members, mostly cotton and wheat farmers. On average, each WCA member has about 40 ha of irrigated land. The WCA has 16 staff: a manager, an accountant, an inspector, three water masters (*mirab*), and 10 pump controllers.

The Muglon Obi Hayoti WCA has 4887 ha of irrigated land, of which about 58% is devoted to cotton, 34% to wheat, and the remainder to fruits, fodder, and other crops. According to the manager, the WCA charges ISFs on a per-hectare basis because it has not yet installed water meters on each farm. The fee of 36,000 Uzbekistan soum (UZS) per hectare was arrived at by dividing the expected cost of distributing water to farms by the total number of hectares that the WCA serves (the exchange rate is approximately 3000 UZS to 1 USD).

The WCA also provides irrigation water for household subsistence agriculture. Each rural household might have a household plot (*tomorka*) of up to 0.25 ha [51]. Households receive water every Sunday. In return, they mainly contribute labor for canal maintenance. Unfortunately, according to FGD participants, a canal goes through household plots, but the households have not been supportive with canal maintenance. When farmers need water, the households open up the canal gate to their plots. Farmers feel that the households own the canal. Since households pay land and water taxes to

the state, farmers are incapable of enforcing limits on household water use. This has reduced trust within the community.

Based on the WCA annual expenditure, which was calculated at the beginning of 2016, WCA members are supposed to contribute about 197 million UZS for irrigation services each year. As of June 2016, about 22.5 million UZS (approximately 12%) had been collected in cash or in-kind contributions. Nevertheless, the WCA manager was optimistic that the collection rate would improve when WCA members received payment for their cotton harvest. Farmers typically deliver their cotton harvest to the state in October or November, after which it may take two to three months to receive payment through a local bank.

4.1.2. Chashmai Mirob WCA

This WCA is located in the Mirishkor district and was established in February 2006. It has 60 members and covers 3150 ha of irrigated land, about 45% of which is planted by cotton and 45% by wheat. The remaining 10% is devoted to gardening, fodder, and other crops. The WCA also provides water for household plot irrigation.

Despite serving a big group of farmers, the WCA has only eight employees: a manager, an accountant, a cleaner, and four *mirabs*. The manager graduated from Agrarian University with a degree in agronomy. The WCA has benefited greatly from donor support. According to the manager, 12 WCAs in the Mirishkor district received financial, technical, and institutional support from the Rural Enterprise Support Project–Phase II, funded by the World Bank during 2008–2016 specifically to support districts with poorly functioning irrigation systems and low socioeconomic indicators. As a result of this support, WCAs were able to obtain a motorcycle for the manager, bicycles for the *mirabs*, an electric motor generator, a computer, and clothes for the WCA staff. A demonstration farm was also established where farmers can learn about techniques for improving water use efficiency. According to the FDG participants, the most important benefit was the establishment of a WCA office where farmers can meet and discuss issues related to CPR management.

In spite of the WCA manager's technical and professional skills, the WCA has not been able to improve the ISF collection rate, with just 40% of the anticipated revenue collected (which is, however, better than the rate achieved by the Muglon Obi Hayoti WCA). The manager noted that five farmers lift water with pumps from irrigation canals at lower elevations. Electricity costs are, thus, an additional burden to those farmers. To compensate for this, the WCA's general assembly decided to calculate ISFs separately for members using pumps. The fee was set at 16,500 UZS/ha for members who use pumps and 34,000 UZS/ha for other members. Despite this, out of an estimated 120 million UZS, only 48 million UZS had been received as of June 2016. A low ISF collection rate makes it difficult to cover the cost of services and thus difficult to provide them [52]. As a result, farmers become even less inclined to pay the ISFs [7].

The non-payment of ISFs may seriously limit the WCAs' scope and undermine their effectiveness [53]. ISFs are the main source of WCA revenue. They are usually based on area rather than on water use and thus, do not provide an incentive to use water efficiently. The state subsidizes ISF payments for cotton and wheat farmers. Farmers who cultivate fruits and vegetables calculate their ISFs internally, and the rate per hectare is much higher than that for cotton and wheat farmers. State support is provided largely through the farm loan program, in which farmers producing cotton and wheat receive a portion of their expected operating expenses in advance for each season. The loans are not made in the form of cash or credit lines, but rather in the form of accounting transfers registered with banks [54]. According to Wegerich [55], ISFs vary across different WCAs depending on the location, water source (canal or river), and water quality. Energy costs for small on-farm pumping stations (costs of the large pump stations are covered by the state), canal maintenance, hydrological equipment costs, and the quality of irrigation water upstream vs. downstream should be taken into account in the ISF calculation [55]. In practice, however, most WCAs base their ISFs either on the estimate established by neighboring WCAs or on suggestions by local water authorities (e.g., ISAs).

Most canals in the territories of this association were built during the 1970s and require reconstruction. Generally, the *khashar* method is used to collectively clean irrigation canals. In *khashar*, or social labor, members of a community collectively construct, repair, and clean canals and other structures. This practice has survived in many communities throughout Uzbekistan. Even though participation is theoretically voluntary, in practice it is obligatory, as those who refrain from participation are generally charged for water or denied access to it [56]. With regard to households, the WCA manager assigns sections of the canal to be maintained by farmers and by local households. Once the area is delineated, a representative of the households regulates canal maintenance by the households. *Khashar* is carried out at the same time by both farmers and households. Households do not contribute to the ISF and are thus obliged to provide labor for maintenance. According to WCA officials, most households and farmers have been living together and practicing irrigated agriculture for a long time, and this has made collective action for water management easier in this WCA. Almost 70–75% of households can be considered relatives, so trust is very high.

4.2. Challenges Facing the Selected WCAs

The study WCAs have been undergoing a difficult transformation and face numerous challenges (Figure 3). In FGDs and individual interviews, WCA members emphasized the importance of maintaining irrigation and drainage canals. In particular, the irrigation canals are in poor condition as they were built during the 1970s. A recent UNDP study [57] assessed the maintenance level of the irrigation and drainage infrastructure throughout Uzbekistan and concluded that more than 50% of canals require reconstruction or repair. This study confirmed that water loss in the selected WCAs amounted to 40–45%, mainly due to a lack of maintenance.

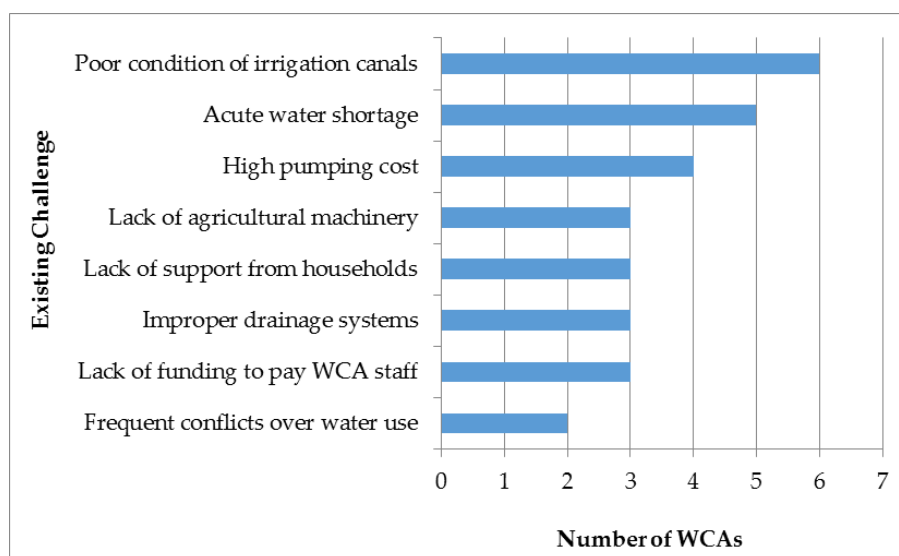


Figure 3. Key challenges identified by the study participants.

Drainage canals were found to be less problematic due to an ongoing government project to systematically clean on-farm and off-farm drainage networks.

Kashkadarya Province faces an acute water shortage due to its reliance on an international water source: the Amudarya River. Presently, about 75% of the irrigated area of the province receives water from this river. Due to the transboundary tensions between upstream countries, which use the river for hydropower, and downstream countries, which use it for irrigation [58], the province is experiencing unreliable and unevenly distributed water resources. This has a substantial effect on farmers in the province, who are fully dependent on irrigation water for crop production. Study participants expressed the concern that due to the mismanagement of water resources, tail-end farmers

suffer from a lack of water, and suggested that WCAs should actively engage in water management and impose tough sanctions on rule-breaking individuals. One member of the Tuychi Ogli Mamurjon WCA said that in the 2016 growing season, he irrigated his wheat field only once and as a result could not meet his wheat quota. He blamed this mainly on his location at the tail end of the canal in an arid zone. Discussions also indicated that water availability was an important factor for improving the ISF collection rate.

The lack of machinery in the WCAs for repairing canals was also frequently noted by WCA members, who believed this to be an important constraint on successful cooperation.

An analysis of the FGDs also revealed that the involvement of local households in CPR management was a commonly discussed topic in the WCAs. Many farmers have been unsatisfied with the way in which most local households have behaved when it comes to water use and canal maintenance. Each local WCA is in charge of providing water to these households for irrigation but, unfortunately, most households do not support collective action, and they have tried to close the water gates serving the entire system and open the gates to their own plots. Some of them have been disinclined to participate in *khashar*. There was no legal mechanism forcing households to pay ISFs until the Cabinet Ministers' Decree No. 82 of March 2013, which gave WCAs more authority to legally punish water-use "free riders" (including local households). However, some WCA members and managers commented that WCAs or farmers who are in charge of the group of households with water delivery and the mobilization of canal maintenance are generally pleased not to impose any monetary charges on local households if they establish an internal mechanism for water access and contributions to canal maintenance.

As can be seen from Figure 3, another major discussion point was the lack of funding to pay WCA staff. WCA employees in the field stressed that ISFs are critical to the long-term survival of WCAs and thus to effective CPR management in the province. For instance, three WCA employees asserted that the main barrier to WCA development has been the lack of payment by members for irrigation services. In theory, these members (resource users) should not receive water if they do not pay their fees. However, according to the WCA employees, the social structure is such that, when wheat and cotton farmers do not receive enough water to enable them to meet state production quotas, they may directly communicate with water authorities (such as their ISA or BISA), and as a result, WCAs are forced to disregard their own rules and provide water, even if they have not been paid. Unless legal penalties for breaking the rules are enforced, it will be difficult for the WCAs to function in the long term. Therefore, it is important to understand power relations between water authorities (ISAs and BISAs) and WCAs, which affect WCAs' institutional mechanisms and practices. Future research should focus on these interrelations.

4.3. Potential Causes of the Problems

Most irrigation and drainage canals in Uzbekistan were built during the Soviet era and require regular maintenance, which the post-independence government of Uzbekistan has not been able to provide. This has left much infrastructure in disrepair. As a result, frequent water shortages and increasing salinity are well-known phenomena in Kashkadarya Province and are hampering crop productivity. Moreover, the main rivers of Central Asia, the Amudarya, Syrdarya, and Zarafshan, are turbid rivers. Sedimentation is a major challenge that reduces the volume capacity of reservoirs and the water discharge carrying capacity of rivers, irrigation canals, and drainage systems. Massive areas in Central Asia were converted to irrigated agriculture during the Soviet period to grow water-intensive crops such as cotton, rice, and wheat, and this dramatically accelerated soil erosion by water and wind. Furthermore, runoff from irrigated fields and the discharge of drainage flow from the Amudarya River sub-basins to the river itself increased sedimentation in the river. The steep slopes of the Amudarya tributaries in the river formation zone have also contributed to increasing sedimentation. As a result, many reservoirs and rivers have high sedimentation rates [59]. Bucknall et al. [41] reported a high silt content in the Amudarya River (up to 6 kg of silt and sand per 1 m³ of water), which requires farmers

to undertake constant canal maintenance. Many water facilities in the basin are currently silted up. In order to address this issue, canal maintenance is required on average three to four times a year, compared to one or two times a year in other provinces of Uzbekistan. About 40–45% of the water from on-farm irrigation channels is lost each year due to the poor condition of the irrigation and drainage systems (personal communication with Amu-Kashkadarya BISA official in 2016). Rehabilitation of these canals requires significant investment and most importantly, the ownership rights for these canals need to be clearly defined.

This study found that most WCAs lack the proper institutional background for effective farm management and good governance. Despite having a good education, WCA officials have a limited authority and knowledge with respect to water distribution. Meetings with WCA members are held only a few times a year. This is also because farmers are occupied with crop production throughout the year. WCAs are incapable of collecting ISFs. Most study participants proposed supporting WCAs by purchasing agricultural machinery (such as excavators and cranes), but were not willing to invest in spare parts and maintenance. It is important to keep investing in capacity-building activities and pushing for a comprehensive legal and regulatory framework for WCAs.

The financial sustainability of WCAs is essential to improving farm management and increasing farm productivity in Kashkadarya Province. The rehabilitation of older irrigation infrastructure is key to improving water use and thus achieving sustainability. A lack of attention has left much of the infrastructure in poor condition, which has led to a reduction in crop yields and an expansion of weeds and silt in the farm canals. It has hindered the timely allocation of water, which has made farmers dissatisfied and reduced their ability and willingness to pay ISFs and thus support WCA operations. ISF collection rates in Kashkadarya Province are not promising (Figure 4). Experts interviewed for this study said that the Kitob and Yakkabog districts are located close to a mountainous area with relatively high precipitation and are mainly oriented to fruits. The WCAs in these districts have abundant water due to their location close to the head of the Kashkadarya River. The experts believed that WCAs in these districts have better climatic conditions, which allow greater crop productivity and thus income. However, WCA members believe that increasing prices for cotton and wheat would raise incentives for farmers to pay their ISFs. FGD participants noted that, under a 2013 government program promoting water-saving techniques such as drip irrigation, farmers can be released from unified land taxes for five years and cultivate secondary crops after cotton and wheat, which can increase farm income and improve the ISF collection rate.

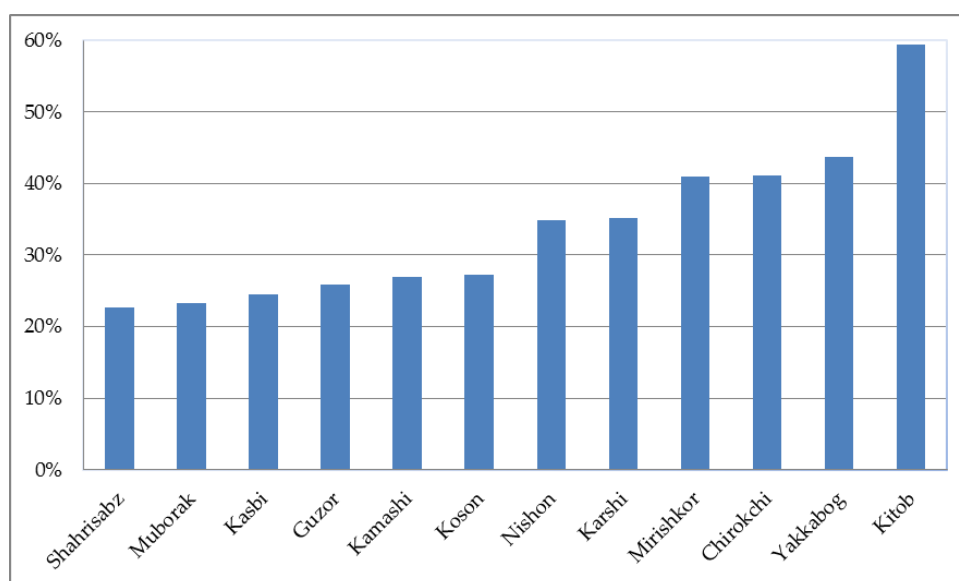


Figure 4. ISF collection rates in all districts of Kashkadarya Province as of June 2016.

4.4. Common-Pool Resources Management in Uzbekistan

Since declaring its independence, Uzbekistan has undergone substantial reform of irrigated agriculture through externally imposed institutional change in the form of the top-down implementation of the WCA system. However, this has not produced the expected results of successful cooperation in the CPR management, and most associations have undergone a difficult transformation [19]. Although WCAs were introduced in Uzbekistan about two decades ago (in the late 1990s) with donor and government support, they are still not widely accepted by individual resource users and they are institutionally weak. Quinn et al. [11] emphasized the importance of informal institutions in CPR management, particularly in developing countries, because many resource-use decisions are made on the basis of traditional norms, few of which are codified in law. Hagedorn, who argued that achieving sustainable resource use is primarily a question of institutional change [60], also noted that informal institutions have persisted due to social values and human capital [61]. He suggested that, while formal institutions can be suddenly changed by a society-altering event such as a revolution, informal institutions (such as social customs and norms) cannot be changed easily [61]. Empirical evidence leads to the conclusion that incongruity between formal institutions and prevailing (informal) institutions has heavily influenced CPR management in Uzbekistan. Despite formal rules on how irrigation water distribution and canal maintenance should be organized and paid for, most farmers still cling to pre-Soviet and Soviet practices. For instance, farmers signed a formal agreement to pay a WCA for irrigation services, but most did not fulfill that agreement.

It is generally assumed that post-socialist countries, including Uzbekistan, suffer from a low degree of social capital; a deficit which tends to hamper cooperation and trust. The findings of this study indicate that when farmers and local households are rooted in an area, meaning that they have been living together and practicing irrigated agriculture for a long time, collective action for CPR management is easier and the trust level is relatively high.

Another widely accepted notion is that the lack of cooperation in the management of irrigation systems is due to the domination of institutionalized Soviet mental and behavioral patterns among WCA members. Studies have referred to the concept of path dependence to illustrate the persistence of old institutions in spite of reforms. During interviews, WCA managers affirmed that even though the state provided some room for organizing collective action at the local level, WCA members rarely design their own rules and cooperate effectively in managing the CPR. Instead, they expect local authorities to either maintain the irrigation canals or tell resource users how to maintain them.

5. Conclusions

This study indicated ways to improve irrigation management in post-socialist transitional settings. Thus far, it seems that top-down institutional design, as in the case of Uzbekistan, can only be successful when it is embedded in settings that make it a de facto form of bottom-up institutional design. The study results suggest that, due to path dependence and mutual resource dependence, successful institutional design should take into account the power relations between higher-level water authorities and WCAs.

This study showed that WCA development is an integral step in the reform of irrigation management programs that is currently underway in Kashkadarya Province. A number of lessons can be learned from the two decades of WCA experience in the province:

- Maintaining on-farm irrigation and drainage canals is the foundation for improving land quality and achieving sustainable irrigated agriculture. Irrigation canals were built during the Soviet period and require massive reconstruction, as most are filled with silt.
- Financing for rehabilitation to make irrigation networks reasonably functional plays a critical role in increasing farm productivity and thus, farmer income.
- Collecting adequate service fees is necessary for the long-term existence of WCAs. A new mechanism of ISF collection needs to be introduced.

- Availability of important agricultural machinery and canal-cleaning equipment, as a part of the rehabilitation effort, contributes to creating a good environment for profitable agriculture production.
- Trust and communication within a WCA play an important role in successful collective action for CPR management. Households and local farmers who have been living together and practicing irrigated agriculture for a long time have shown the greatest success in this regard.

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References

1. Rap, E.; Wester, P. The practices and politics of making policy: Irrigation management transfer in Mexico. *Water Altern.* **2013**, *6*, 506–531.
2. Ward, F.A. Financing irrigation water management and infrastructure: A review. *Int. J. Water Resour. Dev.* **2010**, *26*, 321–349. [[CrossRef](#)]
3. Hamidov, A. Institutions of Collective Action for Common Pool Resources Management: Conditions for Sustainable Water Consumers Associations in Semi-Arid Uzbekistan. Ph.D. Thesis, Humboldt University of Berlin, Berlin, Germany, 2015.
4. Ostrom, E. Reformulating the commons. *Swiss Polit. Sci. Rev.* **2000**, *6*, 29–52. [[CrossRef](#)]
5. Vermillion, D. Property rights and collective action in the devolution of irrigation system management. In *Collective Action, Property Rights and the Devolution of Natural Resource Management: Exchange of Knowledge and Implications for Policy*; Deutsche Stiftung fuer Internationale Entwicklung: Puerto Azul, Philippines, 1999.
6. Abdullaev, I.; Kazbekov, J.; Manthritlake, H.; Jumaboev, K. Water user groups in Central Asia: Emerging form of collective action in irrigation water management. *Water Resour. Manag.* **2010**, *24*, 1029–1043. [[CrossRef](#)]
7. Zavgorodnyaya, D. Water User Associations in Uzbekistan: Theory and Practice. Ph.D. Thesis, Center for Development Research (ZEF), University of Bonn, Bonn, Germany, 2006.
8. Sehring, J. Path dependencies and institutional bricolage in post-soviet rural water governance. *Water Altern.* **2009**, *2*, 53–60.
9. Ostrom, E. *Governing the Commons: The Evolution of Institutions for Collective Action*; Cambridge University Press: Cambridge, UK, 1990.
10. Hardin, G. The tragedy of the commons. *Science* **1968**, *162*, 1243–1248. [[CrossRef](#)] [[PubMed](#)]
11. Quinn, C.H.; Huby, M.; Kiwasila, H.; Lovett, J.C. Design principles and common pool resource management: An institutional approach to evaluating community management in semi-arid Tanzania. *J. Environ. Manag.* **2007**, *84*, 100–113. [[CrossRef](#)] [[PubMed](#)]
12. Cousins, B. Tenure and common property resources in Africa. In *Evolving Land Rights, Policy and Tenure in Africa*; Toulmin, C., Quan, J.F., Eds.; Department for International Development (DFID), International Institute for Environment and Development (IIED), Natural Resources Institute (NRI): London, UK, 2000; pp. 151–180.

13. Demsetz, H. Toward a theory of property rights. *Am. Econ. Rev.* **1967**, *57*, 347–359.
14. Simmons, R.T.; Smith, F.L., Jr.; Georgia, P. *The Tragedy of the Commons Revisited: Politics Versus Private Property*; Center for Private Conservation: Washington, DC, USA, 1996.
15. Ophuls, W. Leviathan or oblivion. In *Toward a Steady State Economy*; Daly, H.E., Ed.; Freeman: San Francisco, CA, USA, 1973; Volume 214, pp. 215–230.
16. Zinzani, A. Hydraulic bureaucracies and Irrigation Management Transfer in Uzbekistan: The case of Samarkand Province. *Int. J. Water Resour. Dev.* **2016**, *32*, 232–246. [CrossRef]
17. Theesfeld, I. A Common Pool Resource in Transition: Determinants of Institutional Change for Bulgaria's Postsocialist Irrigation Sector. Ph.D. Thesis, Humboldt University of Berlin, Berlin, Germany, 2005.
18. Zinzani, A. Irrigation Management Transfer and WUAs' dynamics: Evidence from the South-Kazakhstan Province. *Environ. Earth Sci.* **2015**, *73*, 765–777. [CrossRef]
19. Hamidov, A.; Thiel, A.; Zikos, D. Institutional design in transformation: A comparative study of local irrigation governance in Uzbekistan. *Environ. Sci. Policy* **2015**, *53*, 175–191. [CrossRef]
20. Olson, M. *The Logic of Collective Action: Public Goods and the Theory of Groups*; Harvard University Press: Cambridge, MA, USA, 1965.
21. World Bank. *Uzbekistan: On the Path to High-Middle-Income Status by 2030*; World Bank: Washington, DC, USA, 2016; Available online: <http://www.worldbank.org/en/results/2016/04/13/uzbekistan-on-the-path-to-high-middle-income-status-by-2050> (accessed on 19 April 2017).
22. Micklin, P.P. *Managing Water in Central Asia*; Royal Institute of International Affairs: London, UK, 2000.
23. Webber, H.A.; Madramootoo, C.A.; Bourgault, M.; Horst, M.G.; Stulina, G.; Smith, D.L. Water use efficiency of common bean and green gram grown using alternate furrow and deficit irrigation. *Agric. Water Manag.* **2006**, *86*, 259–268. [CrossRef]
24. FAO. *The Water-Energy-Food Nexus: A New Approach in Support of Food Security and Sustainable Agriculture*; Food and Agricultural Organization of the United Nations: Rome, Italy, 2014; Available online: http://www.fao.org/nr/water/docs/FAO_nexus_concept.pdf (accessed on 6 March 2017).
25. Hamidov, A.; Helming, K.; Balla, D. Impact of agricultural land use in Central Asia: A review. *Agron. Sustain. Dev.* **2016**, *36*. [CrossRef]
26. Libert, B.; Lipponen, A. Challenges and opportunities for transboundary water cooperation in Central Asia: Findings from UNECE's regional assessment and project work. *Int. J. Water Resour. Dev.* **2012**, *28*, 565–576. [CrossRef]
27. Horst, M.G.; Shamutalov, S.S.; Pereira, L.S.; Goncalves, J.M. Field assessment of the water saving potential with furrow irrigation in Fergana, Aral Sea basin. *Agric. Water Manag.* **2005**, *77*, 210–231. [CrossRef]
28. Sun, S.K.; Wang, Y.B.; Liu, J.; Cai, H.J.; Wu, P.T.; Geng, Q.L.; Xu, L.J. Sustainability assessment of regional water resources under the DPSIR framework. *J. Hydrol.* **2016**, *532*, 140–148. [CrossRef]
29. Abdullaev, I.; Hassan, U.; Mehmood, M.; Herath, Y. *The Reliability Improvement in Irrigation Services: Application of Rotational Water Distribution to Tertiary Canals in Central Asia*; International Water Management Institute (IWMI): Colombo, Sri Lanka, 2006; Volume 100.
30. Bedrintsev, K.; Korzhavin, B. *Irrigation of Uzbekistan: Irrigation Development in a Complex of Production Forces of Uzbekistan*; Fan: Tashkent, Uzbekistan, 1975; Volume 1, p. 351. (In Russian)
31. Yusupov, Y.; Lerman, Z.; Chertovitskiy, A.; Akbarov, O. *Livestock Production in Uzbekistan: Current State, Issues and Prospects*; United Nations Development Programme: Tashkent, Uzbekistan, 2010.
32. Trevisani, T. Land and Power in Khorezm: Farmers, Communities, and the State in Uzbekistan's Decollectivisation. Ph.D. Thesis, Freie University of Berlin, Berlin, Germany, 2008.
33. Törhönen, M.-P. Land tenure in transition: Case Uzbekistan. In Proceedings of the XXII FIG Congress, ACSM-ASPRS Conference, Washington, DC, USA, 19–26 April 2002.
34. Abdullaev, I.; De Fraiture, C.; Giordano, M.; Yakubov, M.; Rasulov, A. Agricultural water use and trade in Uzbekistan: Situation and potential impacts of market liberalization. *Int. J. Water Resour. Dev.* **2009**, *25*, 47–63. [CrossRef]
35. Khodjaev, S.; Avazov, I. *IWMI Performance Indicators to Assess Performance of Irrigation Systems in the Kashkadarya River Basin, Uzbekistan*; Tashkent Institute of Irrigation and Melioration: Tashkent, Uzbekistan, 2011.
36. Sadikov, A.S.; Mamarasulov, S.M.; Poslavskiy, V.V. *Irrigation in Uzbekistan: Current State and Prospects of Irrigation Development in the Amudarya River Basin*; Tashkent, Uzbekistan, 1979; pp. 57–63. (In Russian)

37. IWMI. *Overview of the Existing River Basins in Selected Regions and Selection of Pilot River Basins*; Internal Report; International Water Management Institute-Central Asia office: Tashkent, Uzbekistan, 2016.
38. Edlinger, J.; Conrad, C.; Lamers, J.P.A.; Khasankhanova, G.; Koellner, T. Reconstructing the spatio-temporal development of irrigation systems in Uzbekistan using Landsat time series. *Remote Sens.* **2012**, *4*, 3972–3994. [[CrossRef](#)]
39. MAWR. *Karshi Pumping Cascade Rehabilitation Project (Phase 1)*; Environmental Assessment final report; Ministry of Agriculture and Water Resources: Tashkent, Uzbekistan, 2001.
40. Tolstov, S. *Along Ancient Deltas of Oks and Yaksart Rivers*; Oriental Literature Publishing House: Moscow, Russia, 1962.
41. Bucknall, J.; Klytchnikova, I.; Lampietti, J.; Lundell, M.; Scatasta, M.; Thurman, M. *Irrigation in Central Asia: Social, Economic and Environmental Considerations*; World Bank: Washington, DC, USA, 2003.
42. Buytaert, W.; Zulkafli, Z.; Grainger, S.; Acosta, L.; Alemie, T.C.; Bastiaensen, J.; De Bièvre, B.; Bhusal, J.; Clark, J.; Dewulf, A. Citizen science in hydrology and water resources: Opportunities for knowledge generation, ecosystem service management, and sustainable development. *Front. Earth Sci.* **2014**, *2*, 26. [[CrossRef](#)]
43. O’Keeffe, J.; Buytaert, W.; Mijic, A.; Brozovic, N.; Sinha, R. The use of semi-structured interviews for the characterisation of farmer irrigation practices. *Hydrol. Earth Syst. Sci.* **2016**, *20*, 1911–1924. [[CrossRef](#)]
44. Mill, J.S. *A System of Logic*, 8th ed.; Longmans, Green and Company: London, UK, 1872.
45. Przeworski, A.; Teune, H. *The Logic of Comparative Social Inquiry*; Krieger Publishing Company: Malabar, FL, USA, 1982.
46. Seawright, J.; Gerring, J. Case selection techniques in case study research—A menu of qualitative and quantitative options. *Political Res. Q.* **2008**, *61*, 294–308. [[CrossRef](#)]
47. Speer, J. Participatory Governance, Accountability, and Responsiveness: A Comparative Study of Local Public Service Provision in Rural Guatemala. Ph.D. Thesis, Humboldt University of Berlin, Berlin, Germany, 2011.
48. Bitsch, V. Focus group discussions as a research and extension method: The case of personnel management issues in horticultural businesses. *Acta Hortic.* **2004**, 461–469. [[CrossRef](#)]
49. Yin, R. *Case Study Research Design and Methods*, 4th ed.; SAGE Publications Ltd.: London, UK, 2009.
50. Frieze, S. *Qualitative Data Analysis with ATLAS.ti*; SAGE Publications Ltd.: London, UK, 2014.
51. Veldwisch, G.J.A.; Bock, B.B. Dehkans, diversification and dependencies: Rural transformation in post-Soviet Uzbekistan. *J. Agrar. Chang.* **2011**, *11*, 581–597. [[CrossRef](#)]
52. Veldwisch, G.J.A.; Mollinga, P.P. Lost in transition? The introduction of water users associations in Uzbekistan. *Water Int.* **2013**, *38*, 758–773. [[CrossRef](#)]
53. Moss, T.; Hamidov, A. Where water meets agriculture: The ambivalent role of the water users associations (WUAs). In *Society–Water–Technology: A Critical Appraisal of Major Water Engineering Projects*; Hüttl, R.F., Bens, O., Bismuth, C., Hoechstetter, S., Eds.; Springer International Publishing: Dordrecht, The Netherlands, 2015; pp. 149–167.
54. Anarbekov, O.; Wichelns, D.; Akramov, I. Assessing the financial and economic viability of water user associations and canal management organizations in Ferghana Valley countries of Central Asia. In Proceedings of the Inter-Conference Symposium on Agricultural Transitions along the Silk Road Restructuring, Resources and Trade in the Central Asia Region, Almaty, Kazakhstan, 4–6 April 2016.
55. Wegerich, K. *Water User Associations in Uzbekistan and Kyrgyzstan: Study on Conditions for Sustainable Development*; School of Oriental and African Studies (SOAS), University of London: London, UK, 2000.
56. Rakhmatullaev, S.; Bazarov, D.; Kazbekov, J. Historical irrigation development in Uzbekistan from ancient to present: Past lessons and future perspectives for sustainable development. In Proceedings of the Third International Conference of International Water History Association, Alexandria, Egypt, 11–14 December 2003.
57. UNDP. *Water—Critical Resource for Uzbekistan’s Future*; United Nations Development Program: Tashkent, Uzbekistan, 2007.
58. Zhupankhan, A.; Tussupova, K.; Berndtsson, R. Could changing power relationships lead to better water sharing in Central Asia? *Water* **2017**, *9*, 139. [[CrossRef](#)]
59. Rakhmatullaev, S.; Huneau, F.; Celle-Jeanton, H.; Le Coustumer, P.; Motelica-Heino, M.; Bakiev, M. Water reservoirs, irrigation and sedimentation in Central Asia: A first-cut assessment for Uzbekistan. *Environ. Earth Sci.* **2013**, *68*, 985–998. [[CrossRef](#)]

60. Hagedorn, K. *Integrative and Segregative Institutions: A Dichotomy for Understanding Institutions of Sustainability*; Humboldt University of Berlin: Berlin, Germany, 2008.
61. Hagedorn, K. The political economy and institutional evolution of privatisation and restructuring of agricultural land in Central and Eastern Europe. In Proceedings of the Regional Conference on Land Issues in Central and Eastern Europe and the CIS, Budapest, Hungary, 3–6 April 2002.



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